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RESEARCH MEMORANDUM

EFFECT OF FUSELAGE FENCES ON THE ANGLE-OF-ATTACK SUPERSONIC PERFORMANCE OF A TOP-INLET - FUSELAGE CONFIGURATION

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
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Page 12, figure 6(f): The curves for total-pressure recovery have been plotted one grid square too high on the scale. The scale should read .40, .60, .80, and .100.

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RESEARCH MEMORANDUM

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SUMMARY

An investigation of the effect of longitudinal body fences on the performance of a top-inlet - fuselage combination was conducted in the NACA Lewis 8- by 6-foot supersonic wind tunnel. Thrust-minus-drag performance for the fence configuration with a typical turbojet-engine installation was compared with that for a bottom-inlet and a top-inlet configuration without body fences. The investigation was conducted at free-stream Mach numbers of 1.5 to 2.0, angles of attack of 0° to 9°, and for a range of inlet mass-flow ratios.

Results of the investigation indicated that the thrust-minus-drag of the top-inlet configuration with fences was higher than that for the bottom-inlet configuration without fences over most of the angle-of-attack range, but the reverse was true for the entire range of lift coefficient at Mach 2.0 and for the higher lift coefficients at Mach 1.8. The addition of fences improved the top-inlet configuration thrust-minus-drag for most of the range of lift coefficient.

INTRODUCTION

The pressure recovery of scoop-type inlets located on the top surface of a body is often penalized at angle of attack because of boundary-layer thickening and body cross-flow phenomena (refs. 1 and 2). However, the drag rise with angle of attack is less for top-inlet configurations than that for bottom-inlet configurations (ref. 2). As a result of this lower drag rise, the thrust-minus-drag performance of top-inlet configurations may compare quite favorably with that of bottom-inlet configurations for certain operating conditions. A device designed to reduce or eliminate the unfavorable flow conditions at the entrance of a top inlet without appreciably increasing the configuration drag would improve the thrust-minus-drag performance, thus making the comparison of a top-inlet with a bottom-inlet configuration even more favorable.

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As a result of these considerations, an investigation of the effect of longitudinal body fences on the performance of a top-inlet configuration was conducted. A bottom-inlet configuration was also included in the investigation to make the comparison more complete. The investigation was conducted at free-stream Mach numbers of 1.5 to 2.0, angles of attack of 0° to 9°, and for a range of inlet mass-flow ratios.

SYMBOLS

The following symbols are used in this report: 3510

C_D	drag coefficient, $D/q_0 S_m$
C_L	lift coefficient, $L/q_0 S_m$
C_M	pitching-moment coefficient about body station 45, moment/$q_0 S_m l$
D	drag
F	internal thrust of turbojet-engine-and-inlet combination
F_i	internal thrust of turbojet-engine-and-inlet combination for 100-percent inlet total-pressure recovery
L	lift
l	body length, 73.125 in.
M	Mach number
m_2/m_0	mass-flow ratio, unity when free-stream tube as defined by cowl lip enters inlet
P	total pressure
p	static pressure
q_0	free-stream dynamic pressure, $\frac{\gamma}{2} p_0 M_0^2$
r	local body radius
S_m	maximum cross-sectional area of model, 33.41 sq in.
x	local body station measured from nose of body
α	angle of attack, deg
γ	ratio of specific heats

Subscripts:

0 free stream

2 diffuser discharge

APPARATUS AND PROCEDURE

A sketch of the model investigated is shown in figure 1. The model consisted of the NACA RM-10 body and a two-dimensional ramp-type inlet. All details of the model, strain-gage balance, support system, and pressure instrumentation are similar to those of reference 2 with the exception that the inlet ramp angle was increased to 19°. As a result of this increase, it was necessary to alter the ramp projection ahead of the cowl lip to maintain approximately the same inlet supercritical mass-flow ratio. The forward portion of the cowl was modified to conform with the increased ramp angle, and the boundary-layer wedge position with respect to the ramp leading edge was altered slightly for structural reasons. Details of the inlet are illustrated in figure 2 and the subsonic-diffuser area variation is shown in figure 3.

The test was conducted with three model configurations: (1) a bottom-inlet configuration, (2) a top-inlet configuration, and (3) a top-inlet configuration with longitudinal body fences.

Dimensions of the fuselage-fence configuration investigated are shown in figure 4 and a photograph of the complete model with fences installed is shown in figure 5. The fences were fabricated of 0.081-inch-thick sheet metal and fastened to the fuselage skin.

Reduction of data for the complete test was similar to that of reference 2. The investigation was conducted in the Lewis 8- by 6-foot supersonic wind tunnel at free-stream Mach numbers of 1.5, 1.8, and 2.0; angles of attack of 0°, 3°, 6°, and 9°; and for a range of inlet mass-flow ratios. Reynolds number range for the investigation was from 26.9×10^6 to 33.0×10^6 based on model length.

RESULTS AND DISCUSSION

Basic Model Data

Inlet total-pressure recovery and model drag coefficient as a function of mass-flow ratio for four angles of attack and three free-stream Mach numbers are shown in figure 6 for the bottom-inlet, top-inlet, and top-inlet-with-fences configurations. For the bottom inlet

(figs. 6(a) to (c)), only a slight variation in the pressure-recovery - mass-flow-ratio curves is observed with angle of attack, whereas the increase in drag coefficient is quite pronounced. The top inlet (figs. 6(d) to (f)) exhibits large decreases in mass flow and pressure recovery with increasing angle of attack and only slight changes in drag coefficient. Addition of fuselage fences to the top-inlet configuration affects inlet pressure recovery and configuration drag coefficient as shown in figures 6(g) to (i). No change in supercritical mass-flow ratio is observed for angles of attack up to 6°. Decreases in inlet pressure recovery with increasing angle of attack were somewhat less 3510
than that noted for the top inlet without fences. The addition of fences also produced a slightly greater increase in drag coefficient with angle of attack at free-stream Mach numbers of 1.8 and 2.0.

Model lift, drag, and pitching-moment coefficients for the three configurations investigated are shown in figure 7 as a function of angle of attack for three free-stream Mach numbers and supercritical inlet operation. Variation and magnitudes of the lift, drag, and moment coefficients for the top- and bottom-inlet configurations were similar to those reported in reference 2. The addition of fuselage fences to the top-inlet configuration increased the zero-angle-of-attack lift and drag coefficients. Lift curve slopes were approximately the same as those for the top-inlet configuration without fences, but the drag rise with angle of attack increased somewhat at Mach numbers of 1.8 and 2.0. Pitching-moment coefficients generally showed a very slight increase with the addition of fences for most of the range of test conditions, while little or no change in the slope of the curves was observed.

Evaluation of Configuration Performance

Variation of the ratio of configuration thrust-minus-drag to ideal thrust with angle of attack is presented in figure 8 for free-stream Mach numbers of 1.8 and 2.0. Inlet operation at a diffuser-discharge Mach number of 0.21 was assumed together with a typical turbojet engine operating at 35,000-foot altitude. None of the three configurations investigated showed any marked degree of thrust-minus-drag superiority over either of the other two for the entire range of angle of attack. For the top-inlet configuration with fuselage fences, the thrust-minus-drag was generally higher than that for the bottom-inlet configuration for all but the very low angles of attack. Thrust-minus-drag for the top-inlet configuration without fences was higher than that for the fence configuration at only the high and low angles of attack.

Ratio of configuration thrust-minus-drag to ideal thrust of figure 8 is presented as a function of model lift coefficient in figure 9. Addition of the fuselage fences to the top-inlet configuration increased the thrust-minus-drag for most of the range of lift coefficient, particularly at a free-stream Mach number of 1.8. The thrust-minus-drag for the bottom-inlet configuration was greater than either of the top-inlet configurations for the entire range of lift coefficient at a free-stream Mach number of 2.0 and for the higher lift coefficients at a free-stream Mach number of 1.8. The top-inlet configuration with fences had values of thrust-minus-drag greater than that for the bottom-inlet configuration for only a limited range of lift coefficient at a free-stream Mach number of 1.8.

SUMMARY OF RESULTS

An investigation of the effect of longitudinal body fences on the performance of a top-inlet - fuselage combination was conducted at free-stream Mach numbers of 1.5 to 2.0 for a range of model angles of attack and inlet mass-flow ratios. The following results were obtained:

1. None of the three configurations investigated (bottom inlet, top inlet, top inlet with fences) showed any marked degree of thrust-minus-drag superiority over either of the other two for the entire range of angle of attack or free-stream Mach number.

2. The addition of fuselage fences to a top-inlet configuration resulted in an improvement in thrust-minus-drag over that obtained with a bottom-inlet configuration for most of the angle-of-attack range, but the reverse was true for the entire range of lift coefficient at Mach 2.0 and for the higher lift coefficients at Mach 1.8.

3. Fuselage fences improved the thrust-minus-drag performance of a top-inlet configuration for most of the range of lift coefficient.

Lewis Flight Propulsion Laboratory
National Advisory Committee for Aeronautics
Cleveland, Ohio, October 11, 1954

REFERENCES

1. Hasel, Lowell E.: The Performance of Conical Supersonic Scoop Inlets on Circular Fuselages. NACA RM L53I14a, 1953.

2. Kremzier, Emil J., and Campbell, Robert C.: Angle-of-Attack Supersonic Performance of a Configuration Consisting of a Ramp-Type Scoop Inlet Located Either on Top or Bottom of a Body of Revolution. NACA RM E54C09, 1954.

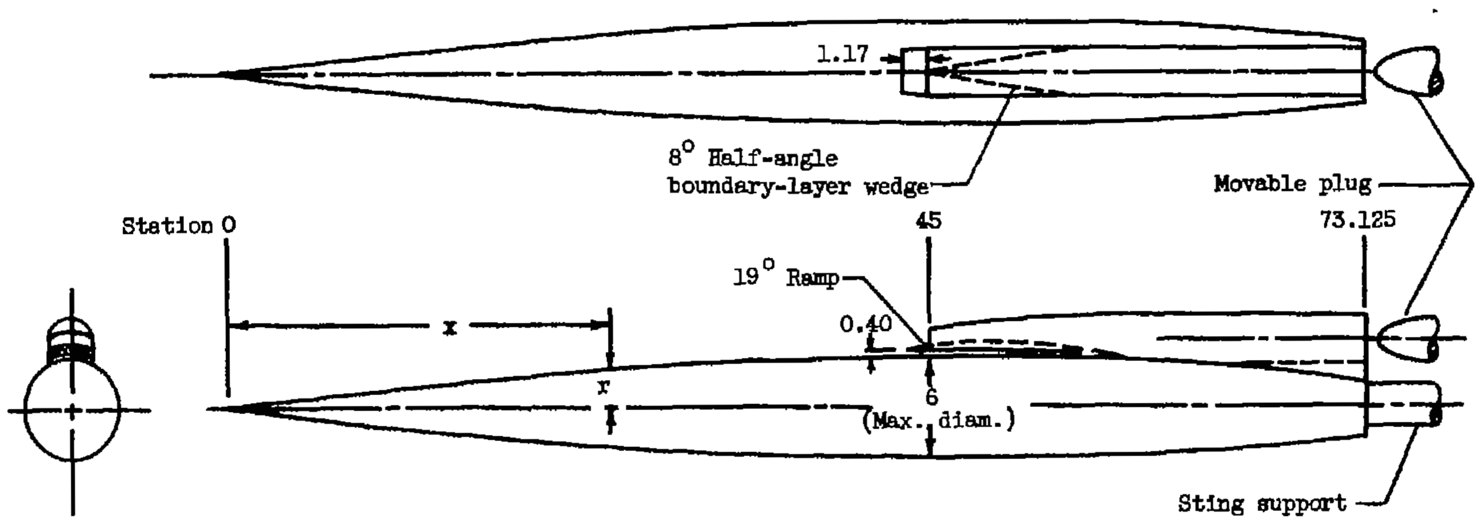

Figure 1. - Sketch of model investigated. Body defined by $r = \frac{x}{15}\left(2 - \frac{x}{45}\right)$. (Dimensions are in inches.)

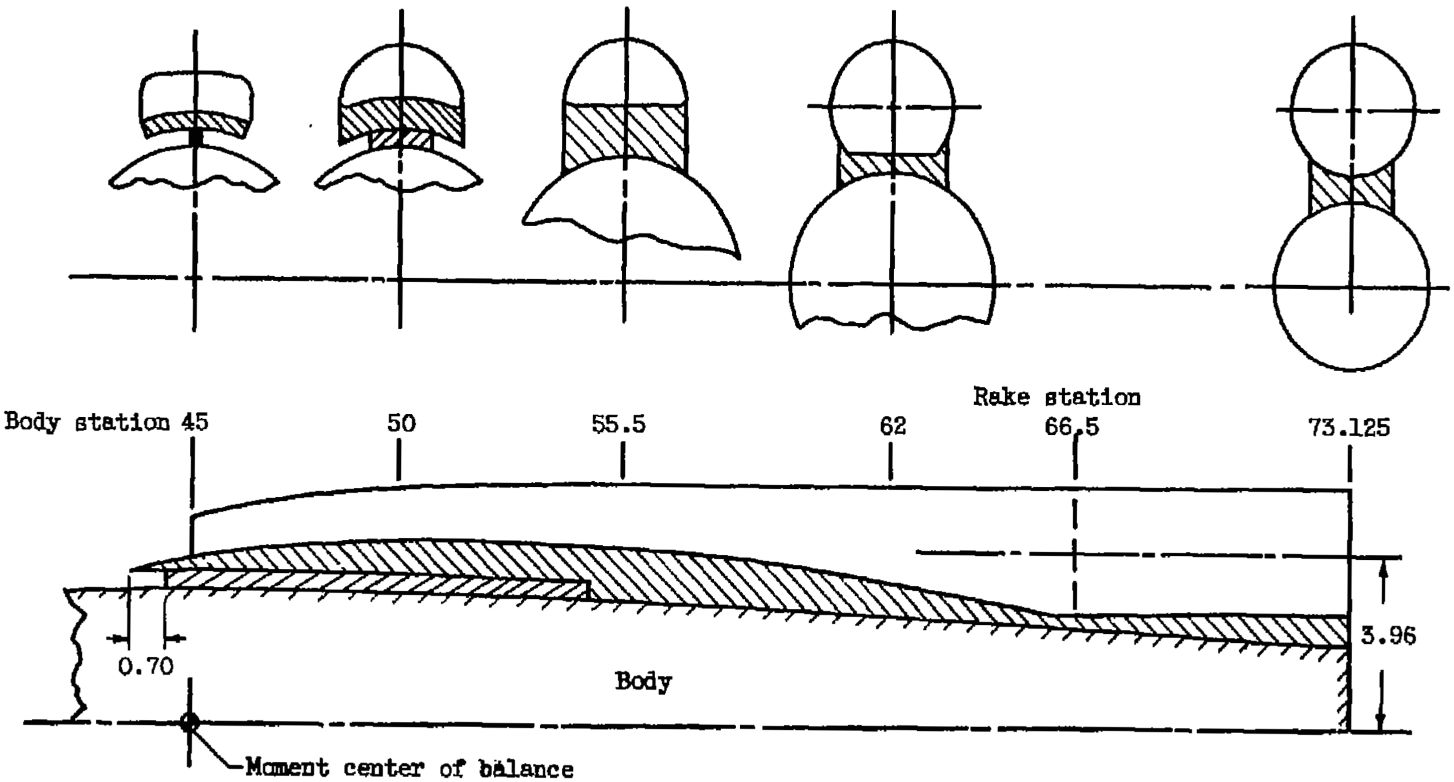

Figure 2. - Details of inlet. (Dimensions are in inches.)

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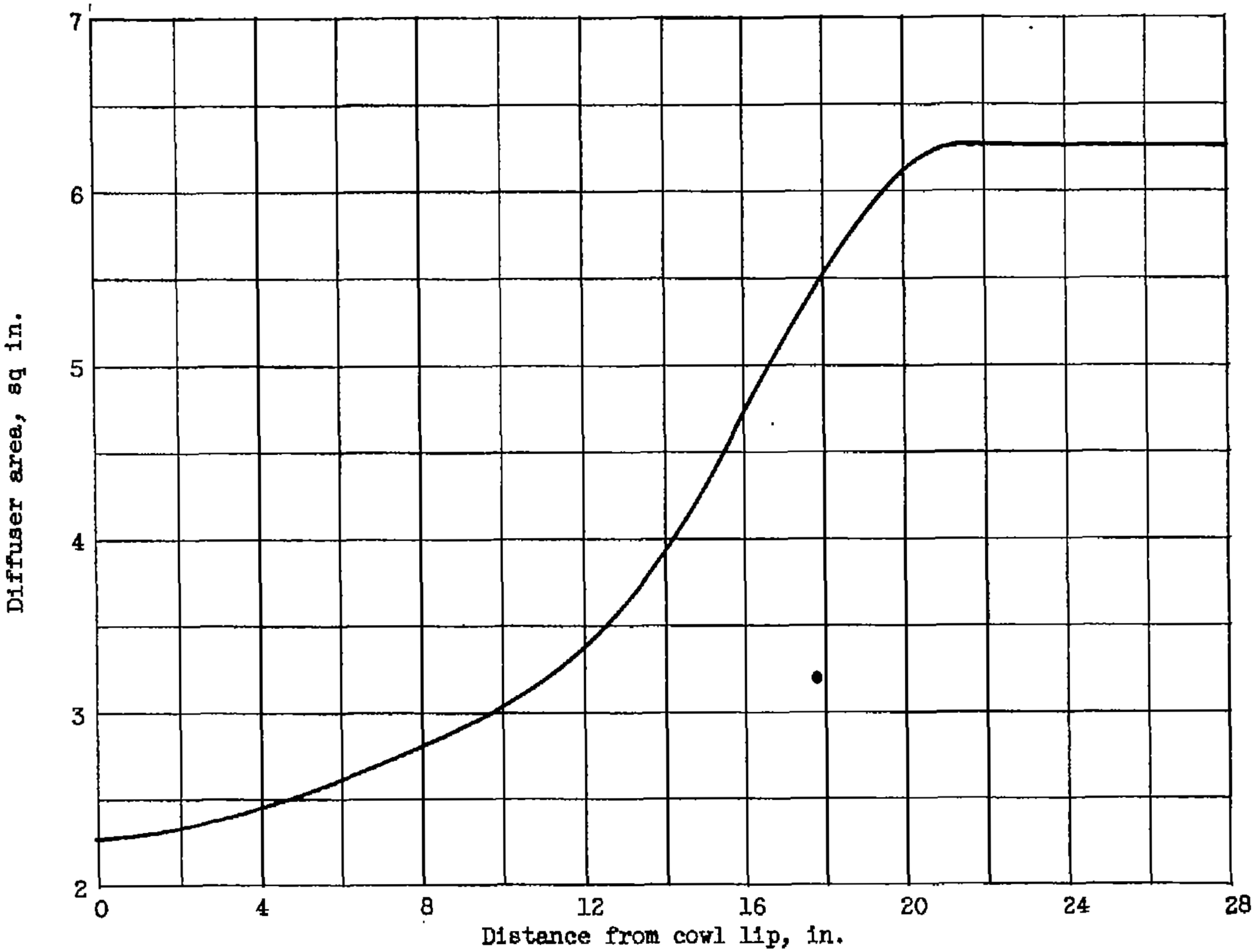

Figure 3. - Subsonic diffuser-area variation.

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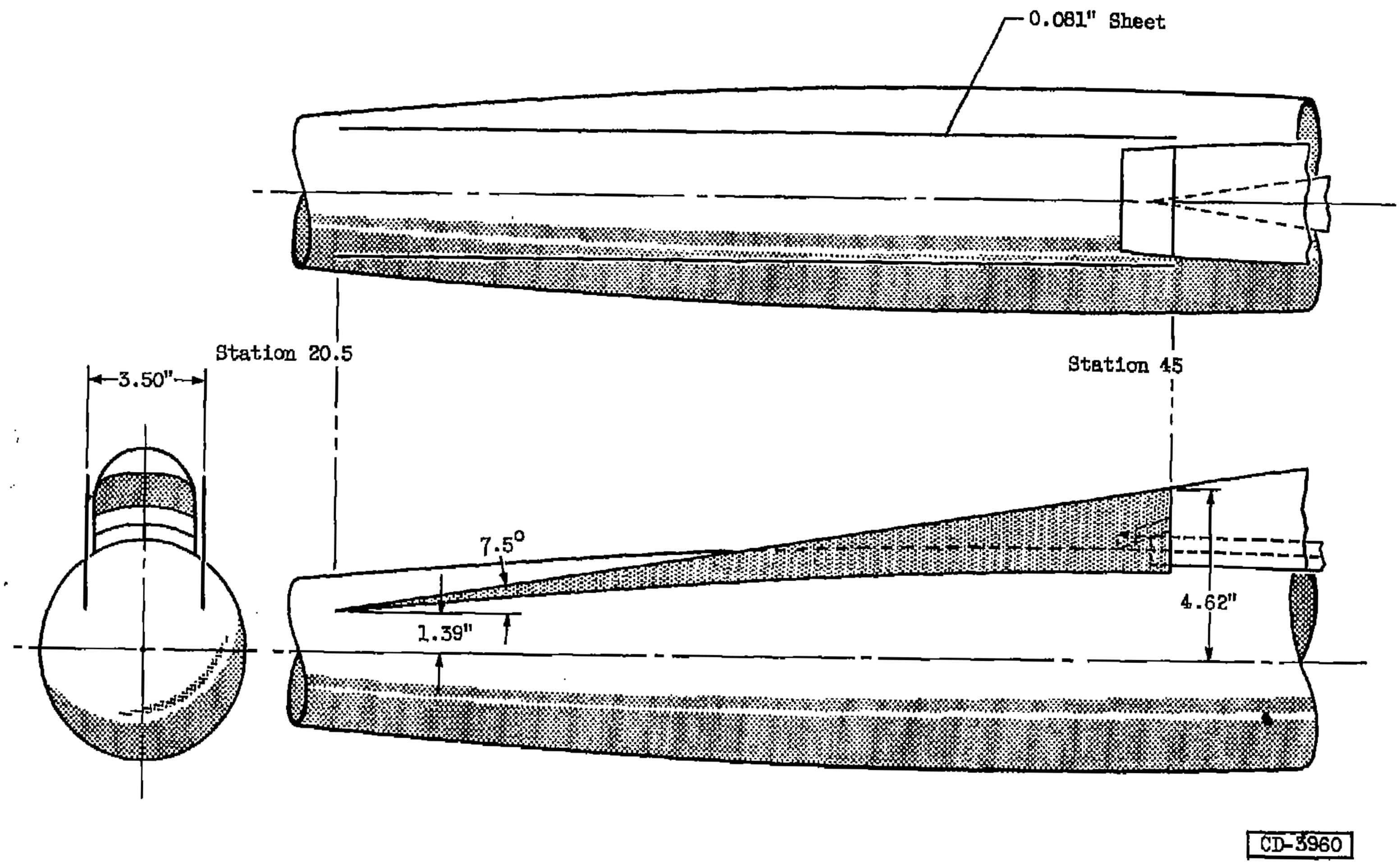

Figure 4. - Details of fuselage forebody fences.

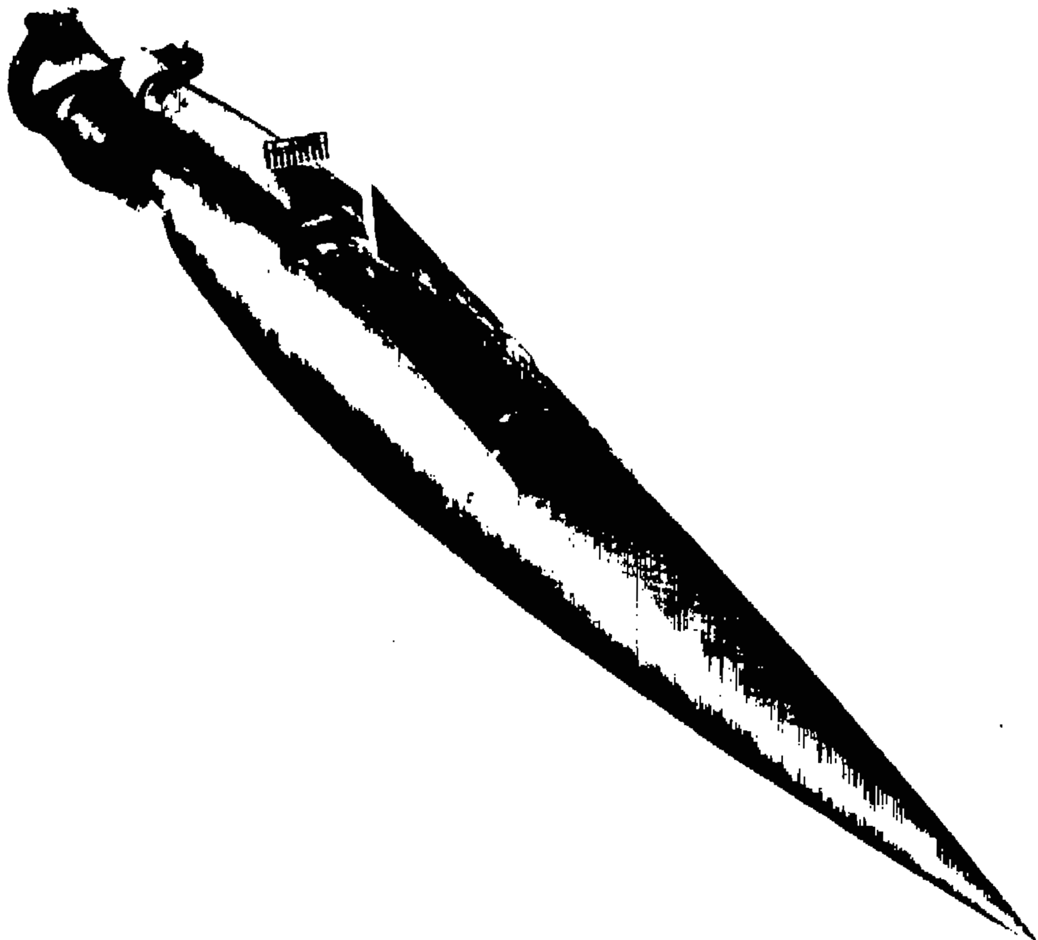

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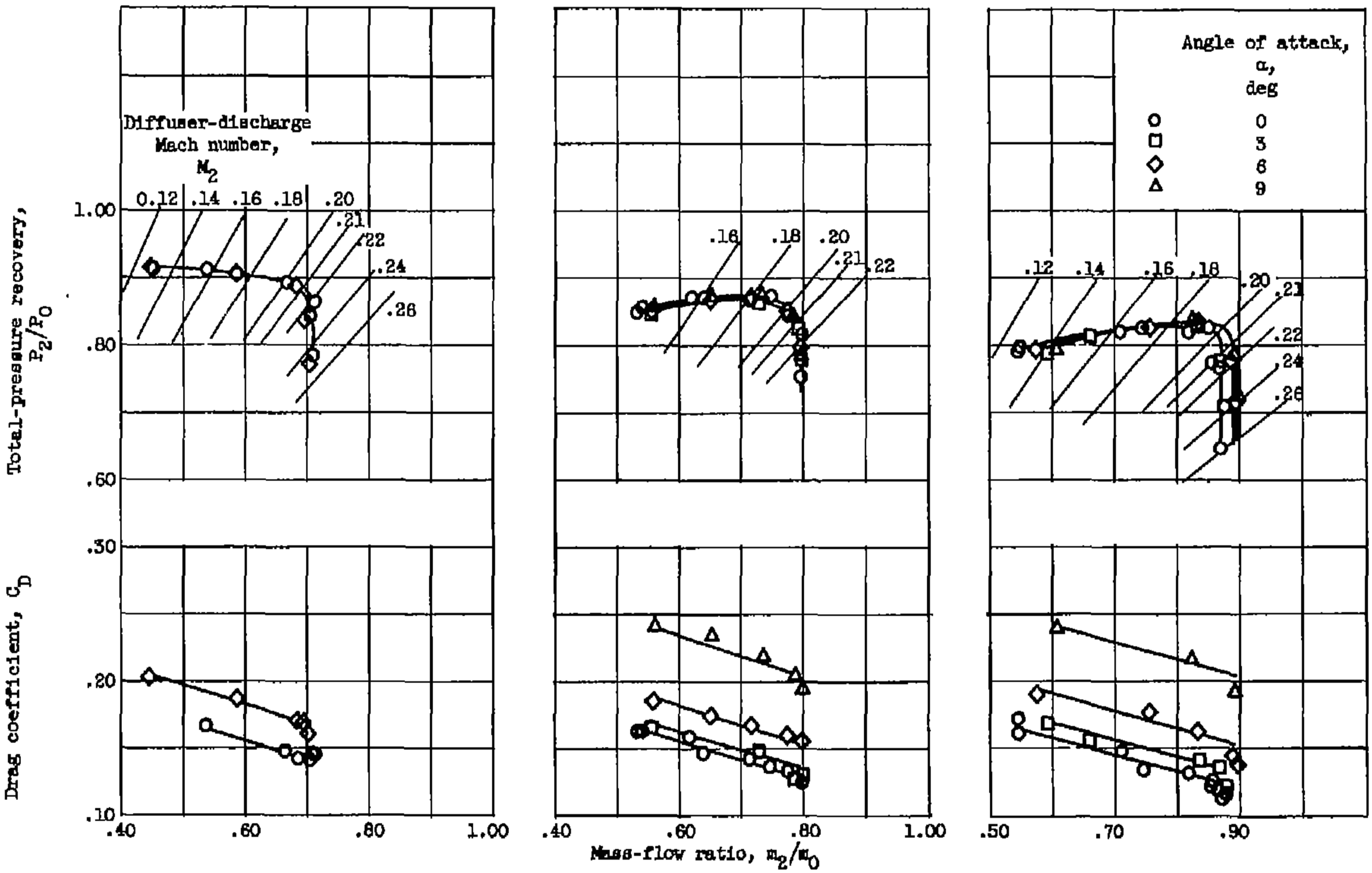
Figure 5. - Model with fences installed.

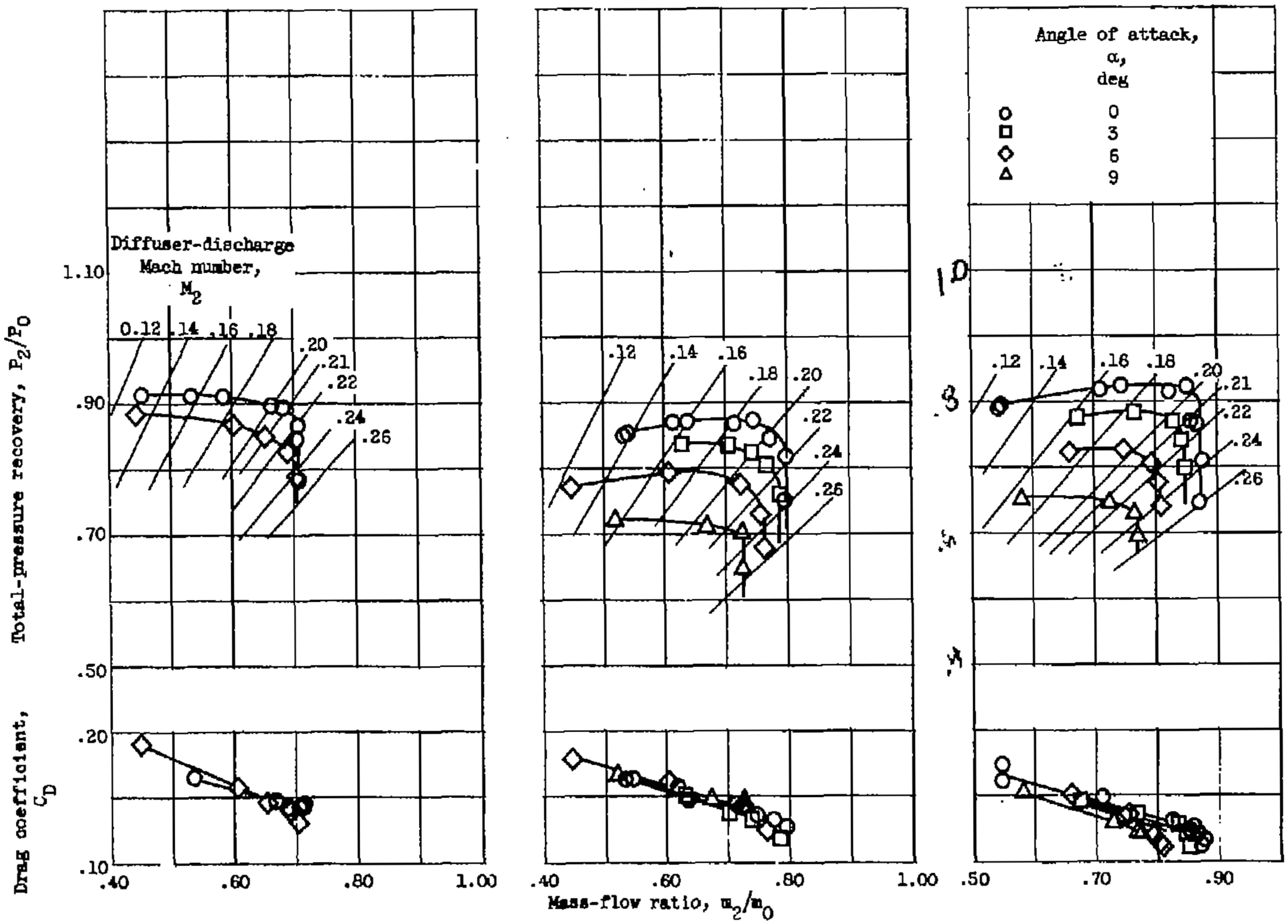


(a) Bottom inlet; M_0 = 1.5.

(b) Bottom inlet; M_0 = 1.8.

(c) Bottom inlet; M_0 = 2.0.

Figure 6. - Variation of pressure recovery and drag coefficient.

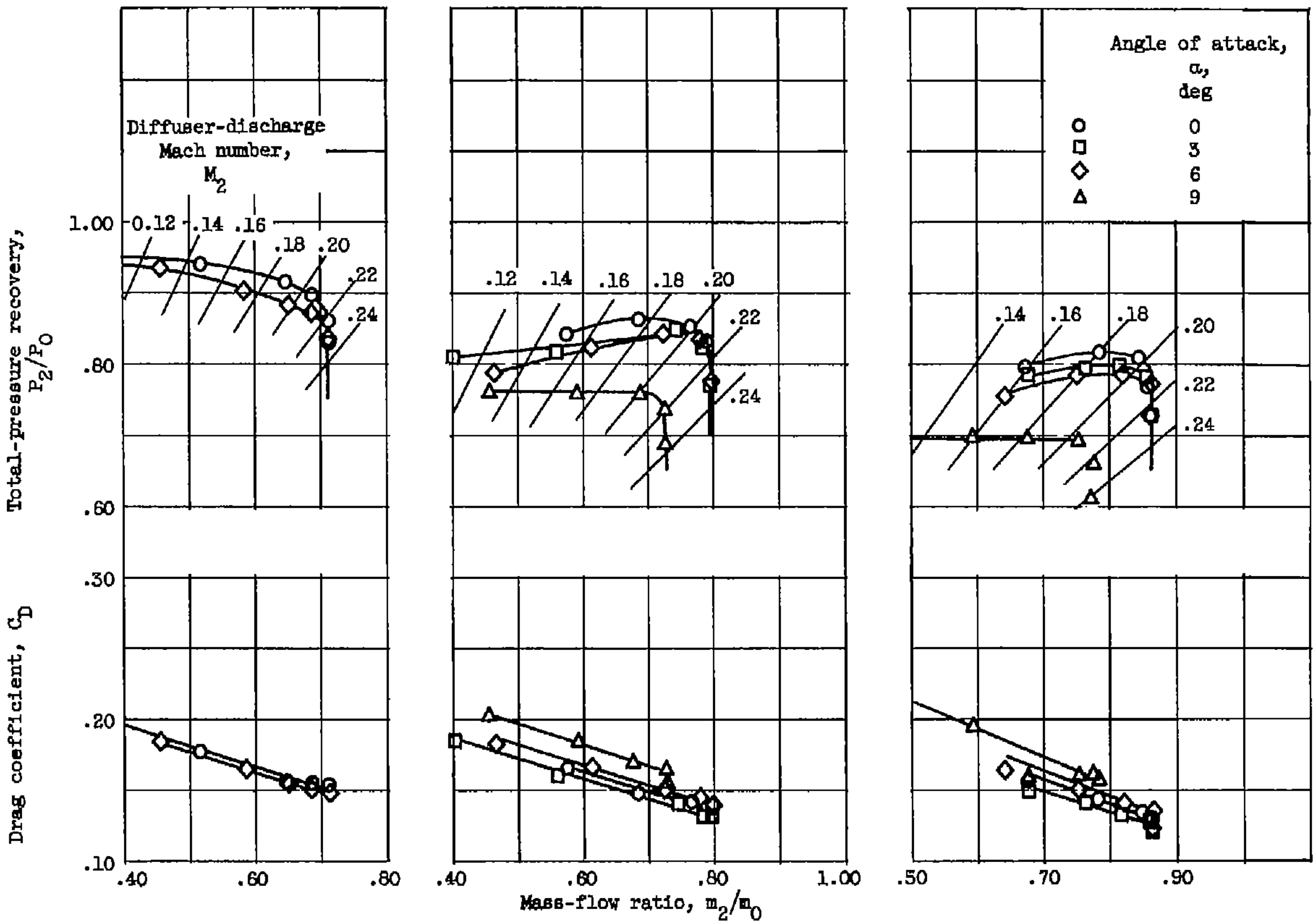


(d) Top inlet; M_0 = 1.5.

(e) Top inlet; M_0 = 1.8.

(f) Top inlet; M_0 = 2.0.

Figure 6. - Continued. Variation of pressure recovery and drag coefficient.

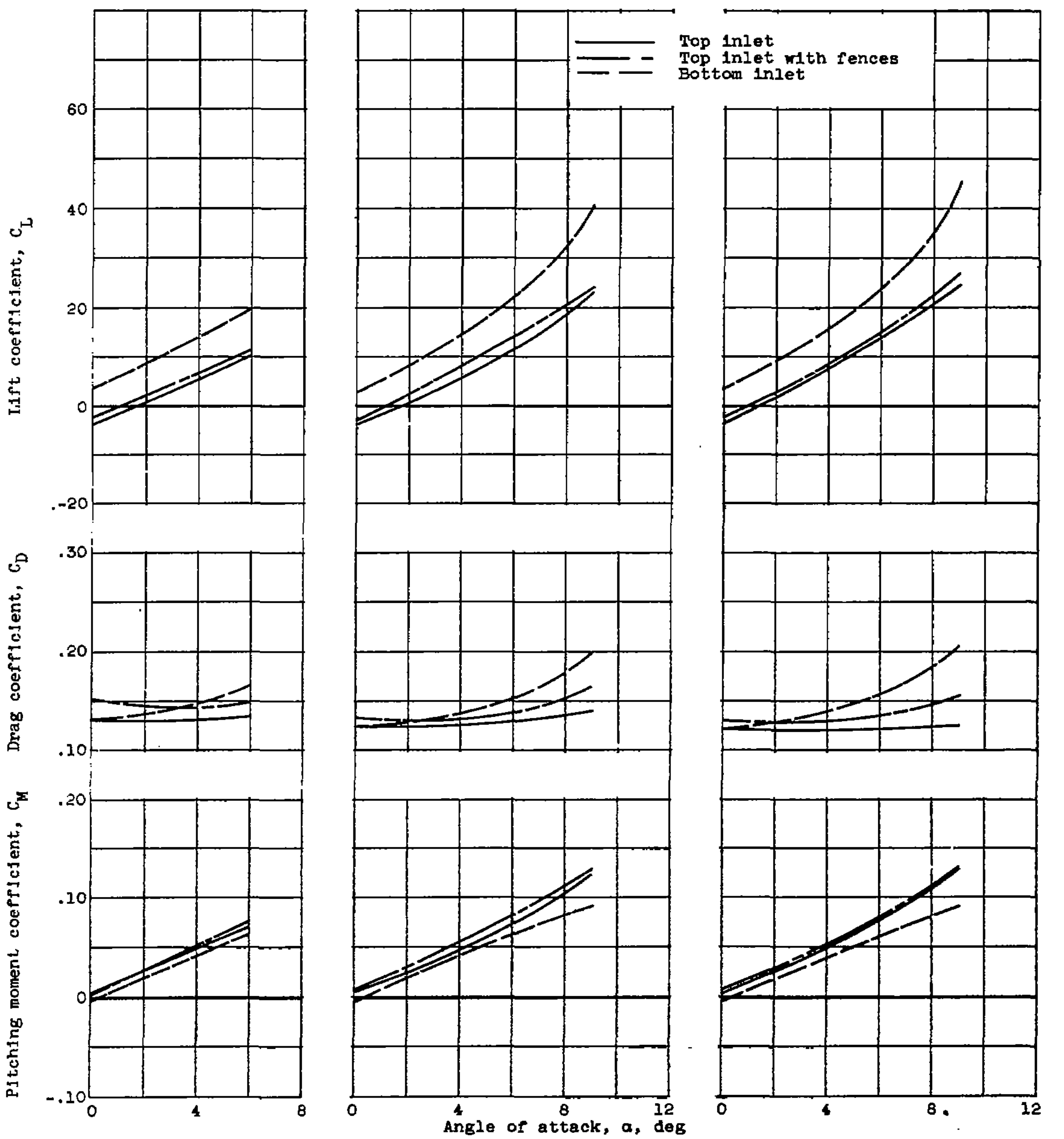


(g) Top inlet with fences; M_0 = 1.5.

(h) Top inlet with fences; M_0 = 1.8.

(i) Top inlet with fences; M_0 = 2.0.

Figure 6. - Concluded. Variation of pressure recovery and drag coefficient.

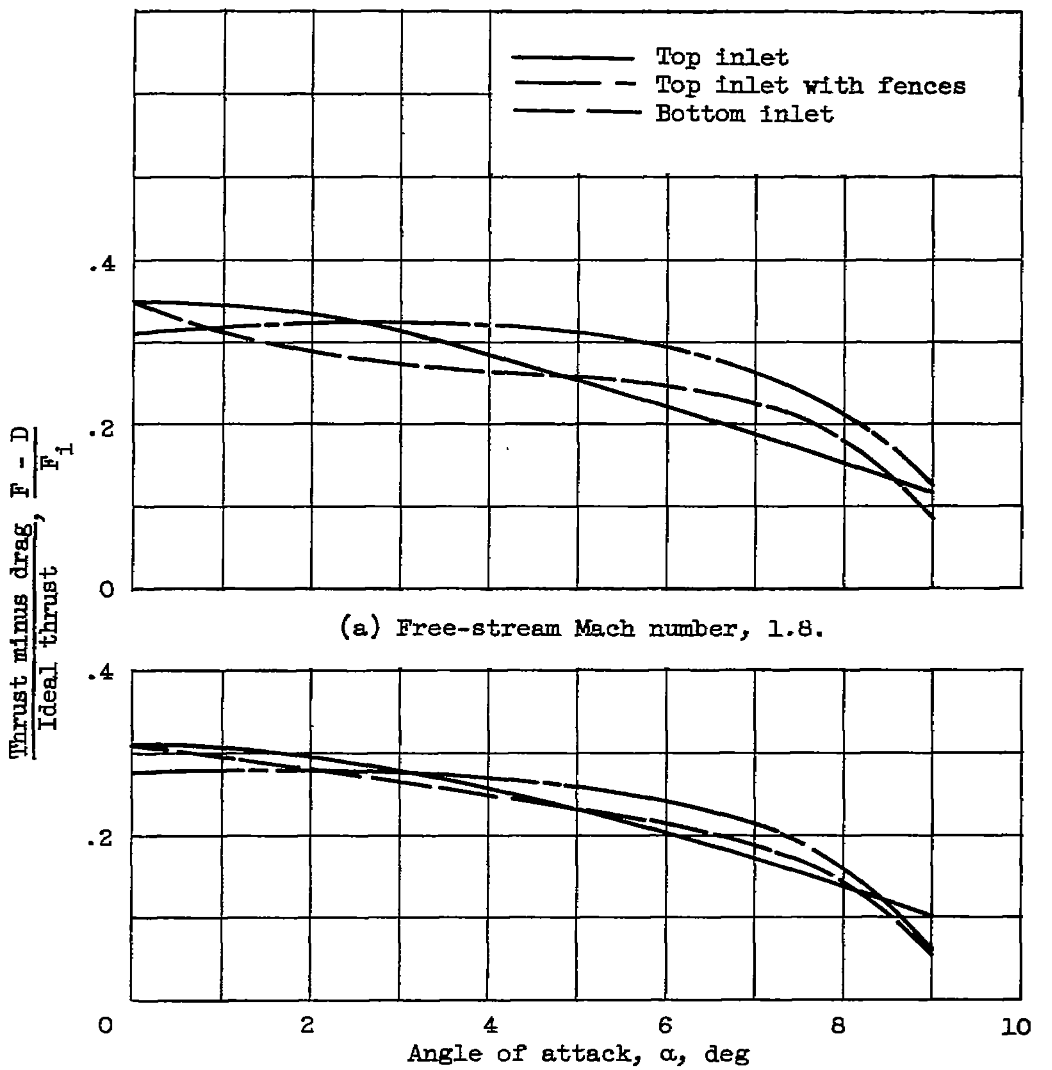


(a) Free-stream Mach number, 1.5.

(b) Free-stream Mach number, 1.8.

(c) Free-stream Mach number, 2.0.

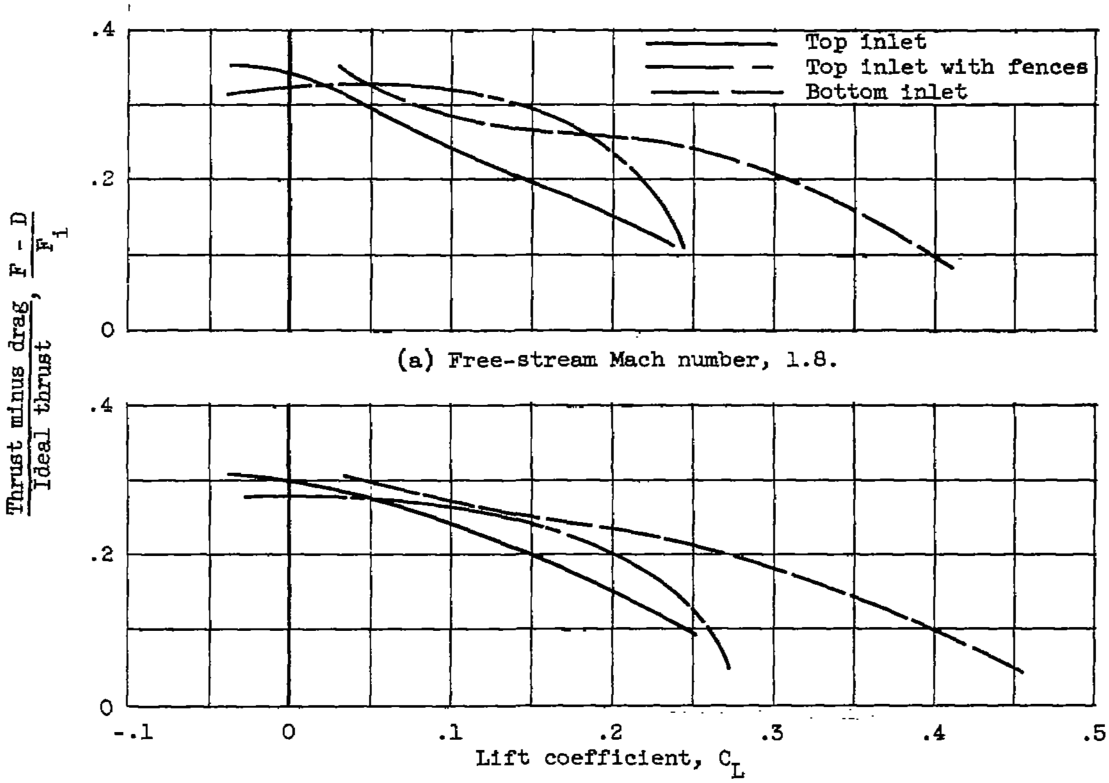
Figure 7. - Variation of force and moment coefficients with angle of attack. (Supercritical inlet operation.)



(a) Free-stream Mach number, 1.8.

(b) Free-stream Mach number, 2.0.

Figure 8. - Ratio of thrust-minus-drag to ideal thrust as a function of angle of attack. Diffuser-discharge Mach number, 0.21; altitude, 35,000 feet.



(a) Free-stream Mach number, 1.8.

(b) Free-stream Mach number, 2.0.

Figure 9. - Ratio of thrust-minus-drag to ideal thrust as a function of model lift coefficient. Diffuser-discharge Mach number, 0.21; altitude, 35,000 feet.

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